CHAPTER 5

Female Genito-Pelvic Reflexes and their Sexual Implications: an Overview

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Submitted for publication.

ABSTRACT

The female reproductive system includes an active and responsive genital tract that shows involuntary activity triggered by sexual arousal, genital stimulation and/or orgasm. This pelvic and perineal somatic and autonomic reflex muscle activity ('genito-pelvic reflexes') may be an important constituent of the female sexual response. The aim of this study was to review the literature critically on female genito-pelvic reflexes and their sexual implications.

Only a small number of studies (fifteen), practically all from one research group, have been published on female genito-pelvic reflexes and their sexual implications. In most studies female genito-pelvic reflexes are suggested to enhance sexual performance or to play a role in sexual dysfunction. However, there is a lack of hard evidence that supports these assumptions. More neurophysiological research is needed to confirm the implications of these genito-pelvic reflexes for sexual (dys)function.

INTRODUCTION

Female genital responses rely on an active and responsive genital tract that shows involuntary activity triggered by – or associated with – sexual arousal, genital stimulation and/or orgasm [1-2]. This pelvic and perineal reflexive muscle activity ('genito-pelvic reflexes') may be an important constituent of female sexual (dys)functioning. A reflex is defined as an automatic stereotyped response to a specific stimulus, mediated by the central nervous system. It requires an intact reflex arc, i.e. a receptor, an afferent and efferent limb, an integrative centre and an effector [3]. However, this definition neither restricts reflexes to the spinal cord nor to skeletal (striated) muscles, which is highly relevant for sexual reflexes. In mammals other than humans, sexual genital responsiveness is under heavy brainstem and diencephalic control [4,5]. In humans it is likely that, even when more expanded cortical and voluntary control is present [6,7], automated or primordial neural control systems give rise to reflexive-like pelvic muscle activity [8].

In line with their embryonic origin, the perineum and pelvic floor are innervated by somatic nerves originating in the sacral spinal cord. This includes all the striated pelvic floor muscles, the genital skin, the anal canal, and the vulva including clitoris, labia and vaginal introitus.

The main somatic nerve of the perineum is the pudendal nerve, which has somatosensory and somatomotor tributaries, and which divides into three main branches (inferior rectal, perineal, dorsal penile/clitoral) at the level of the levator ani muscle. The muscles that embryonically derive from the cloacal sphincter (external anal and urethral sphincter, superficial transverse perineal muscle, bulbocavernosus muscle, and ischiocavernosus muscle) are all innervated by pudendal nerve fibres originating in a specialized sacral motor neuronal pool called Onuf's nucleus [9,10]. As Onuf motoneurons innervate striated muscles but also are known to be relatively unaffected by somatic motoneuron diseases like amyotrophic lateral sclerosis [11], they have been proposed to be of a mixed somatic/autonomic type [12]. Interestingly, the pudendal nerve seems less involved in the innervation of the levator ani muscle. A separate nerve, the 'levator ani nerve' [13], arising from the ventral ramus of the third and fourth sacral nerves, is held to innervate the pelvic diaphragm. In at least 50% of cadavers studied, the pudendal nerve also contributed to innervation of the levator ani muscle, especially in regards to the medial portions (puborectal and pubococcygeal muscles) [14].

Pelvic viscera, including cavernous tissues, contain smooth muscle that is innervated by the autonomic nervous system. Sympathetic innervation derives from preganglionic

motoneurons in the last three thoracic and the first two lumbar spinal cord segments. Post-ganglionic sympathetic fibres may reach the pelvic viscera either via the paired hypogastric nerve which originates from pre-aortic sympathetic ganglia or via branches originating from the sacral continuation of the sympathetic chain ganglia [15]. Thus, the former nerves descend into the pelvis while the latter reach the pelvis viscera from posteriorly. The parasympathetic pelvic splanchnic nerves arise from preganglionic motoneurons in the sacral segments to reach the pararectal pelvic parasympathetic ganglia [15]. The role of the parasympathetic vagal nerve in pelvic innervation is controversial. At the level of the pararectal parasympathetic ganglia the sympathetic and parasympathetic nerve systems become entangled – and probably also interact – to form inferior hypogastric plexuses. Visceral sensory information travels together with the autonomic nerves to enter the spinal cord at corresponding levels. Most of vaginal sensory fibres travel in the parasympathetic pelvic splanchnic nerve [15] or along with the sympathetic fibres arising from sacral sympathetic ganglia. However, the fact that paraplegic women may still perceive deep vaginocervical stimulation and may reach orgasm by virtue of this stimulation strongly suggests that a part of deep vaginal and cervical sensory information travels with the sympathetic hypogastric nerve [16] or possibly even the parasympathetic vagal nerve [17].

A decennia ago, Levin reviewed 6 genital reflexes and described their sexual functionality [1,18]. However, until now, the literature is very scare on the subject of genito-pelvic reflexes and their sexual implications. One of the reasons for scarcity is that measuring reflexes in the human pelvic region is very complicated. In general, electromyography and pressure measurements are used to obtain partly indirect information about genito-pelvic reflexes. Pelvic- and perineal muscles provide poor access for techniques such as surface (non-selective) or intramuscular needle electromyography (selective) techniques that are known to measure reliable estimates of skeletal muscle force [19]. In the case of autonomic reflexes that involve visceral smooth muscles the situation is even more complex, because the physiological properties of smooth muscle do not allow reliable inference of muscle force or activity [20]. Therefore, indirect measures (e.g. measuring intravaginal pressure with a solid state pressure transducer in combination with a balloon-like device) in this research field are used. The aim of the present study is to give an overview of all available studies on female genito-pelvic reflexes and their proposed sexual implications.

METHODS

PubMED was used to identify relevant genito-pelvic reflex studies published between January 1979 and May 2013. Search terms were: *female genito-pelvic reflexes, vaginal reflexes, female sexual reflexes and female pelvic floor reflexes*. All studies published in English that dealt specifically with genito-pelvic reflexes and their sexual implications were included, regardless of their methodological quality. In addition, references lists of identified studies were searched.

RESULTS

First sightings of pelvic reflexes

In 1966, C.A. Ringrose, a Canadian gynaecologist, observed several reflexes or 'neuromuscular phenomena' in the pelvis while taking routine Pap smears. According to Ringrose, securing of the vaginal and cervical samples elicited reflexive contractions. Although these reflexive contractions varied in the degree of intensity, their presence or absence could be perceived clearly by the naked eye. Ringrose was the first to describe, categorize and document the incidence of these reflexes in a group of 137 women who did not have any vaginal complaints. The reactions observed while scraping of the cervix or lateral wall of the upper third of the vagina, were categorised into five groups: 1) no response, 2) contraction of the bulbocavernosus muscle (BCM) on touching the cervix (i.e. cervix-BCM reflex), 3) contraction of the adductor muscles of the thigh on touching the cervix (i.e. cervix-adductor reflex), 4) contraction of the BCM on touching the vagina (vagino-BCM reflex) and 5) contraction of the adductor muscles on touching the vagina (i.e. vagino-adductor reflex). Given the fact that the majority of the women with three or more of these reflexes were in their pre-ovulatory phase, Ringrose suggested that oestrogens influence pelvic reflexive contractions, whereas progesterone attenuates reflex activity. Out of these reflexes, the vagino-BCM reflex had the highest incidence. It was present in 47 out of the 137 women unilaterally and in 22/137 women bilaterally. Ringrose considered that the presence of pelvic reflexes indicated intact vaginal- and cervical receptors, but also noted that the women without pelvic reflexes nevertheless reported satisfactory sexual functioning [2].

Clitoro-pelvic reflex

In 1979, Gillan & Brindley published an article entitled 'Vaginal and pelvic floor responses to sexual stimulation'. Originally, the main purpose of their study was to evaluate the

vaginal vascular responses to vibratory stimulation, recorded as changes in vaginal light reflectance averaged over a cardiac cycle and as thermal conduction from a heated vaginal thermometer. However, during their experiments they were the first to discover that clitoral vibratory stimulation caused reflexive sustained contraction of the pelvic floor muscles. On one occasion, pelvic floor activation by clitoral stimulation was sustained (no orgasm occurred) for 3.5 minutes, without any decline in surface electromyographic(EMG) activity. Gillan & Brindley found that after orgasm, pelvic floor EMG activity remained increased for at least 2 minutes. They called this phenomenon the clitoro-pelvic floor reflex, but did not provide clues as to which particular pelvic floor muscle could be chiefly responsible for the phenomenon. The study confirmed orgasmic contractions and their curiously non-uniform time sequence. According to the authors, the slow relaxation of the pelvic floor muscles after orgasm was a new observation. In this study, vibratory stimulation of the clitoris was performed using a pneumatically coupled stimulator, while pelvic floor EMG measurements were obtained using stainless steel wire electrodes. The experiments were done on a large number of women with a sexual dysfunction. The total number of women and their specific sexual dysfunction was not reported. The authors considered the clitoro-pelvic floor reflex to be the counterpart of the vagino-BCM reflex described by Ringrose. However, Gillan & Brindley stated that in contrast with the phasic vagino-BCM reflex, the clitoro-pelvic reflex was a well-sustained tonic contraction. Unfortunately, the authors did not speclate about the sexual implications of this reflex [21].

Vagino-cavernosus reflex

In 1993, Ahmed Shafik, an Egyptian pelvic surgeon and researcher, published his first study on female genito-pelvic reflexes. Data were obtained from 17 asymptomatic, sexually active women with a mean age of 36.6 years. A vaginal balloon, connected to a catheter, was inserted 3-4 cm into the vaginal canal and concentric needle electromyographic electrodes were inserted into the bulbocavernosus muscle (BCM) and ischiocavernosus muscle ICM). Then air was rapidly pumped into the vaginal balloon, in increments of 50 ml up to a total volume of 300 ml, and any reflexive muscle contractions in both cavernosus bodies were recorded on the EMG equipment. It was found that the two muscles acting on the main cavernous bodies, the BCM and ICM, immediately contracted at a rapid distension volume of only 50 ml. Shafik called this two-muscle contraction the vagino-cavernosus reflex. This reflex could be reproduced and did not arise after anaesthetization of the vagina. Shafik suggested that this reflex

occurs during sexual intercourse and/or vaginal penetration and could enhance clitoral and penile erection. The BCM crosses the clitoris in V-form and, on contraction, it is believed to potentiate clitoral erection by two mechanisms: 1) compression of the deep dorsal vein of the clitoris and 2) compression of the corpus cavernosus. Simultaneously, contraction of the bulbus portion of the muscle would compress the bulbus vestibuli. In combination with compression of the cavernosus tissue resulting from ICM contraction, this would enhance clitoral erection. Shafik also speculated that reflexive contractions may help to milk semen from the penile urethra into the vagina, while the penis is being withdrawn from the vagina after ejaculation and that BCM contraction, during penile penetration, would enhance male penile erection [22].

Vagino-levator reflex

Two years later, in 1995, Shafik reported again a new reflex, probably based on data from the same group of 17 of asymptomatic women (mean age 36.6 years): the vagino-levator reflex. In accordance with Shafik's previous reflex study, he used an EMG concentric needle electrode and a vaginal balloon. On the lateral site to the anal orifice, the EMG electrode was inserted into the levator ani muscle. Shafik reported increased EMG activity in the levator ani muscle on vaginal distension at 50 ml, the mean duration of EMG activity was 2 seconds, whereas at 300 ml inflation, mean duration was approximately 8 seconds. EMG responses did not occur when the vagina or levator ani muscle was anaesthetized. Shafik proposed that this reflex leads to vaginal widening, vaginal elongation (ballooning) and uterus elevation (tenting). He concluded that this reproducible reflex might lead to genital responses that facilitate sexual performance, i.e. upon penile thrusting, levator ani contraction leads to widening of the vaginal introitus (in contrast with the puborectalis reflex), vaginal elongation and ballooning of the upper vagina, as well as uterine elevation (the tenting effect). However, Shafik did not investigate whether the different parts of the levator ani muscle contributed differently to this reflex [23].

Vagino-puborectalis reflex

In 1995, Shafik studied reflexes in the puborectalis muscle in 14 asymptomatic women (mean age 34.8 years) using an inflatable condom-ended catheter (inserted 4-5 cm into the vagina) and a concentric needle electrode inserted in the puborectalis muscle. With air in steps of 50 ml up to a maximum volume of 300 ml, the vaginal balloon was filled. Meanwhile EMG activity in the puborectalis muscle was recorded. Inflating balloon (from

100 to 300ml) increased the EMG up to 8 seconds. Shafik found that vaginal distension evoked contraction of the puborectalis muscle (i.e. a momentary increase in EMG activity) and he named this the puborectalis reflex. After anaesthetization of the vagina with lidocaine gel or (the following day) anaesthetization of the puborectalis muscle with lidocaine injections, there were no responses from the puborectalis muscle to vaginal distension. The results were reproducible in each individual subject. Shafik speculated that during vigorous penile thrusting, the vagina distends and activates two reflexes: the vagino-bulbocavernosus reflex and the vagino-puborectalis reflex. Simultaneous contraction of the two muscles narrows both the vaginal canal and the vaginal introitus, leading to stronger penile erection. He also suggested that the penile sensation from the female muscle contraction is in itself an important erotic stimulus [24].

Vagino-clitoral reflex

In 1995, Lavoisier and co-workers used Doppler ultrasonography to evaluate the response of the clitoral arteries to vaginal pressure stimulation in 10 healthy women, aged 20 to 28 years. A sterile, rigid, cylindrical pressure probe (diameter 2.5 cm; length 13 cm) was used as a stimulator. The distal part of the probe was packed in a rubber balloon that was capable of being filled, connected to a pressure transducer. Hydraulic balloon inflation and pressure monitoring occurred simultaneously. Vaginal pressure stimulation was performed using two methods: 1) cyclic insertion-withdrawal of an already situated vaginal pressure probe and 2) inflation and deflation of a stationary inflated vaginal pressure probe. The authors found that pressure stimulation along the superficial third of the vagina resulted in increased blood velocity and increased flow into the arteries of the clitoris in 90 percent of the women. They named this the 'vagino-clitoral reflex'. They hypothesized that during the insertion and withdrawal movements of sexual intercourse, the glans penis experiences pressure stimulation that triggers both blood flow enhancement into the cavernous arteries and reflex contractions of the ischocavernosus muscle (ICM), resulting in increased intracavernosus pressure and penile rigidity. Similarly, vaginal stimulation triggers vascularization of the clitoris, with increased erotic pleasure, and muscular-reflexive responses, which enhances perivaginal blood flow and tone. On the basis of his findings, Lavoisier suggested that sexual synergy occurs during intercourse, in which vascular and muscular (reflexive) responses in both sexes are reciprocally reinforce [25,1].

Vagino-vesicourethral reflex

In 2001, Shafik and El-Sibai aimed to study the effect of increased vaginal pressure (as in penile thrusting) on the bladder and urethra in 26 asymptomatic female volunteers with a mean age of 36.7 years. In steps of 10 ml, up to a maximum volume of 80 ml, carbon dioxide was pumped into a condom situated in the vagina and connected to a catheter. In response to this vaginal distension, bladder as well urethral pressure was measured by means of a microtip catheter connected to a transducer. In a range of 30 ml up to 80 ml vaginal distension, decreased bladder pressure and increased urethral pressure was reported. The duration of this effect was 4 seconds. This reproducible vesico-urethral pressure response to vaginal distension was labelled the vagino-vesicourethral reflex. When the bladder, urethra and vagina were individually anaesthetized, no pressure responses were observed. During sexual intercourse, this reflex is evoked by penile thrusting and leads to bladder dilatation/relaxation and increased urethral sphincter activity, most likely in order to prevent urinary leakage. According to Shafik, urinary incontinence during sexual intercourse in patients with various neuropathic conditions might be explained by reflex disorders [26].

Vagino-anorectal reflex

In the same year, Shafik and El-Sibai investigated how anorectal function was affected by increased vaginal pressure, following the same inflating procedure. In 24 healthy female volunteers, mean age 39.2 years, rectal and anal responses to vaginal distension were recorded in increments of 10 ml, up to a maximum volume of 80 ml using a two-channel microtip catheter connected to a transducer. At 30 ml and up to 80 ml, vaginal distension resulted in increased anal pressure (suggestive of anal sphincter contraction) and decreased rectal pressure (suggestive of rectal muscle relaxation). After anaesthetization of the vagina, and the internal sphincter, external sphincter and rectum, no vagino-anorectal reflex was observed during vaginal distension. Shafik speculated that repeated penile thrusting compresses the anorectum and shifts its contents towards the anal canal. Then the rectum dilates to accommodate any additional contents from the sigmoid colon, while the anal sphincter contracts to guard against the leakage of flatus or other rectal contents. He hypothesized that the vagino-anorectal reflex prevents the passage of flatus and faeces during sexual intercourse. This reflex could be inhibited in patients with diabetes mellitus or caudal equine lesions, resulting in faecal leakage during sexual intercourse [27]. In 2005, four years after his first description of the vagino-anorectal reflex, Shafik tested the hypothesis that this reflex

functions to prevent escape of flatus and faeces during sexual intercourse. His study population comprised 23 sexually active women, with a mean age of 33.7 years. Needle EMG activity was recorded in the internal anal sphincter, external anal sphincter and rectum. Meanwhile in steps of 50-300 ml, a vaginal balloon was inflated with 300 ml air. The results revealed that vaginal distension reduced the rectal pressure and increased the internal sphincter EMG activity. However, external sphincter EMG activity did not show any response. Shafik postulated that penile thrusting evokes rectal and internal anal sphincter contraction, which is suggestive of the vagino-anorectal reflex. He concluded again that this reflex contributes to preventing the leakage of rectal contents during sexual intercourse [28].

Clitoro-uterine reflex

In 2005, Shafik and colleagues recruited 23 healthy women (mean age 36.7) to test the hypothesis that during sexual intercourse, uterine erection, elevation and enlargement are mediated by reflexes resulting from penile stimulation of the glans clitoris. Uterine and glans clitoris pressures were recorded during glans clitoris stimulation electrically and mechanically with a pencil electrode using a manometric tube. The main goal of the study was to gain insight into uterocervical responses during sexual intercourse. Shafik confirmed the results of previous studies, in which electrical waves were seen on EMG to emanate from the uterus. These waves were believed to be responsible for the motor activity of the uterus [29-31]. At present, there is no consensus regarding the source of the uterine electrical waves [32]. Slow waves were detected by the uterine electrodes, whereas no waves were observed from the glans clitoris. Nevertheless the study results suggested a reproducible reflex between glans clitoris stimulation and the uterus, which the authors referred to as the clitoro-uterine reflex. After cervical dilation and individual anaesthetization of the uterus and glans clitoris, the tests were repeated. Uterine electrical activity was recorded by means of a catheter attached to the uterine wall by suction, which was maintained during the test. Some participants needed sedation (intravenous diazepam) during cervical dilatation. Three electrodes were inserted into the uterus: two into the uterine mucosa (one above the other, 2 cm apart) and one into the cervix uteri (CU) mucosa (in about the middle of the cervical canal). During stimulation of the anaesthetized glans clitoris, no clitoro-uterine reflex was observed. The reflex also remained absent during anaesthetization of the uterus. No sexual implications were suggested [33].

Vagino-tubal reflex

In 2005, Shafik and co-workers conducted a study on oviduct contractile activity during vaginal distension in 16 multiparous women (mean age 32.2 years), who were undergoing an abdominal hernia repair operation, or tubal ligation for sterilization. Vaginal pressure was measured using a cylindrical latex vaginal balloon; tubal pressure was measured by means of an open-tip urethral catheter, perfused with saline. The study revealed that 10 ml of vaginal distension caused an increase in ampullar and isthmic pressures and a decrease in intramural tubal pressure. Shafik named this phenomena the vagino-tubal reflex. Shafik suggested that these tubal pressure changes also occur during sexual intercourse and are mediated by, what he called, the vagino-tubal reflex. In his opinion, the contractile tubal activity assists sperm-ovum transport and fertilization. The reflex was reproducible and disappeared after anaesthetic block of the vagina and anaesthetization of the oviduct, which was accomplished by infusing a solution of lidocaine in saline through the catheter already in situ [31].

Cavernoso-anal reflex

In 2006, Shafik used EMG to measure how the internal and external anal sphincters responded to BCM and ICM contractions in seven healthy women (mean age 38.3 years) without any anorectal or gynaecological complaints. Prior to conducting the tests, the normality of the EMG activity of the BCM and ICM and the two anal sphincters had been verified in all participants. EMG needle electrodes were inserted into both cavernosus muscles and both anal sphincters. Electrical stimulation of the two cavernosus muscles caused increased EMG activity in the internal and external anal sphincters. The reflex was confirmed by its absence during anaesthetization of the cavernosus muscles, nor did anesthetized anal sphincters respond to cavernosus muscles stimulation. Shafik concluded that cavernosus muscle contraction evoked anal sphincter contraction, which seemed to be a reflex mediated through the cavernosa-anal reflex. He speculated that anal sphincter contraction acts to close the anal canal to prevent flatus or faecal leakage during sexual intercourse, in the same way as the vagino-anorectal reflex [34].

Ano-cavernosal excitatory reflex

In 2006, Shafik performed a study on the relation between ICM contraction and external anal sphincter contraction. Measurements were obtained from eight asymptomatic women (mean age 36.8 years) using one EMG needle electrode inserted into the external anal sphincter and one into the ICM. The measurements showed that external anal

sphincter electro-stimulation produced an increase in ICM EMG activity, while voluntary anal squeezing also resulted in increased EMG activity in the ICM. This ICM contraction upon EAS contraction seemed to be mediated by a reflex that he referred to as the 'ano-cavernosal excitatory reflex'. After anesthetization of the external anal sphincter (EAS) and ischocavernosus muscle (ICM) respectively, the reflex did not occur. According to Shafik, EAS contraction presumably acts to prevent the leakage of flatus or fluid stools during sexual intercourse, which might otherwise lead to coitus interruptus [35].

DISCUSSION

In general, genito-pelvic reflexes have been largely ignored in the literature. The aim of the present study was to review research into human female genito-pelvic reflexes and their sexual implications. Several different reflexes have been speculated to act on the female genital tract, and these reflexes have been framed in many different functional contexts, ranging from functional clitoral-vaginal interplay to the promotion of urinary and faecal continence during sexual intercourse. However, as these functional implications were not tested empirically the relevance of female genito-pelvic reflexes for sexual functioning remains largely unknown.

Generally, some important critical comments should be made about the reviewed studies. In future research, these comments should be taken in consideration. Most importantly perhaps, it should be clear that the research method used (peripheral stimulation and measurement) is insufficient to reveal the neurophysiological characteristics of a given reflex-like response. That is, it does not reveal the integral parts of a reflex, namely the receptors, afferent and efferent nerves and synapse centre. One can of course derive that mechanical stimulation (e.g. pressure or moving touch) excites mechanoreceptors, but apart perhaps from the clitoris [36] the receptor constellation in the human vaginal tract is largely unknown. In a similar vein, vaginal afferent information may be conveyed by sacral parasympathetic nerves, by thoracolumbar sympathetic nerves, by sacral sympathetic nerves, and maybe even by the vagal nerve [15]**.** In addition, It is unclear whether different pathways would affect muscular responses via the same reflex centre. In analogy to men, some of the responses found in women could rely upon spinal circuits for genital reflexes. For instance, the male pelvic floor, especially the muscles acting on the urethra, shows rhythmic activity during ejaculation. Parallel, high frequency fluctuations in rectal pressure indicative of fast pelvic floor contractions have been found during orgasm in women. The characteristics of these contractions are strongly suggestive of subcortical control of pelvic motoneurons [37-38]. Possibly, female pelvic

muscle contractions during climax rely on similar spinal control systems as those known to exist in men [4]. Genital responses that occur in spinal cord injured (SCI) women are suggestive that at least some of these reflexes are organized as spinal cord reflexes. SCI women are known to have lubrication and clitoral engorgement upon vulvar touch, while pelvic rhythmic contractions may be intact as well [39]. Nevertheless, the reflexes discussed in this review may be applicable to multiple levels of the central nervous system, and not only the spinal cord.

Another limitation relates to the responses, which are measured from striated or smooth muscle. Striated muscle measurements clearly dominate in the studies reviewed, which makes sense given the much more difficult accessibility of smooth muscle to EMG, leaving only the possibility for indirect measurement. As indicated earlier, muscles that derive from the embryonic cloaca (BCM, ICM, anal and urethral sphincters and possibly also the puborectalis) are controlled by motoneurons in a special sacral nucleus termed Onuf's nucleus [9-10]. Onuf motoneurons can be considered as an intermediate type between somatic and autonomic [12]. Thus, whether responses of striated cloacal muscles must be considered autonomic or somatic is not entirely clear, while it leaves open the possibility that reflex responses of these muscles are controlled by a reflex centre distinct from responses of other striated pelvic muscles. Besides striated muscle activity, smooth muscle activity is important for sexual functioning such as clitoral and vaginal vasocongestion, vulvar and vaginal lubrication, and uterine motility [40]. Vaginal smooth muscles show continuous electrical activity, with spontaneous vaginal motility [21]. This activity, controlled by the autonomic nervous system, is increased at clitoral vibration and during menstruation [40]. Assumed functions of these contractions are clearing the vagina from ex-and secretion products, and possibly activating vaginal blood supply at sexual quiescence [41].

It is striking that most of the studies that were identified have been produced by the same research group, headed by the Egyptian pelvic surgeon Ahmed Shafik. The studies of Shafik have a stereotypic construction; electrical or pressure recording of muscular activity, induced by pressure (inflated balloon) or electrical stimulation. After anaesthetisation tests were repeated. In their studies, Shafik's group consistently evaluated response reproducibility, the absence of responses during anaesthetization and the response latency. However, based on the demographics of the subjects in his studies, some of the studies seem to reflect the same subject cohort. The impression arises that different responses published in different papers (for example the vagino-cavernosus and vagino-levator reflexes) were actually part of the same experiment.

It would be important to know whether multiple reflexes were studied in the same subjects, or whether multiple reflexes were tested in different subjects. Until now, unfortunately, his studies have not been replicated by other research groups. Moreover, in the book 'Bonk, the curious coupling of sex and science' of Mary Roach is reported that Shafik used prostitutes in his studies [Mary Roach, 2008]. It is known that Masters and Johnson abandoned the use of prostitutes in their research when they found genital abnormalities in this group of women, probably from being continually stimulated to arousal without the relief of orgasm [Masters and Johnson, 1966]. Therefore, it can be questioned whether this study group is representable for other women.

Levin pointed out that a short duration of the reflexes (seconds) could severely limit their functionality during coitus unless they were activated repeatedly [1,42]. The duration of the reflexes in the studies of Shafik ranged from 2-8 seconds. Gillan & Brindley stated that in contrast with the phasic vagino-BCM reflex, the clitoro-pelvic reflex was a well-sustained tonic contraction (ranging from 2.0 to 3.5 minutes) [21]. The latest is in line with a study of Broens et al. in which high resolution solid state circumferential catheters were used to measure intravaginal pressures during voluntary contractions and induced reflexive contractions in women without a sexual dysfunction. In their study voluntary contractions were characterized by low(decreasing) and fluctuating pressures of short duration (less than 1.5 minutes). In contrast, reflexive contractions were characterized by much higher (increasing) pressures of a relatively much longer duration (even longer than 6 minutes) [43].

At present, the literature on genito-pelvic reflexes and their sexual implications is very limited. The majority of studies on genito-pelvic reflexes have methodological shortcomings. These shortcomings could relate to; not reporting the reproducibility of the reflex, not performing anaesthetization to check the reflex in absence of an afferent arm, not performing manual examination of pelvic floor muscle strength and tone in order to confirm the absence of pelvic floor hypo- or hyperactivity and not reporting the duration of the reflexive contractions. With the exception of the study of Ringrose (N=137), subject cohorts were relatively small, while almost all the studies described in this overview were performed in sexually functioning women without sexual complaints. Only in Gillian and Brindley's study measurements were performed in women with a sexual dysfunction. Unfortunately their specific sexual dysfunction was not reported [21]. We have the impression that participants were in a neutral state during the measurements, however, in most studies it is not reported whether participants were sexually aroused during the measurements. Therefore, studies are warranted that compare for example

genito-pelvic reflexes between aroused and non-aroused sexually functioning- and dysfunctioning women.

CONCLUSIONS

The number of studies on female genito-pelvic reflexes and their sexual implications is very limited. These reflexes might be involved in clitoral and penile erection, milking semen from the male urethra during sexual intercourse, the tenting effect, and sperm-ovum transport. In several studies, it is suggested that female genito-pelvic reflexes might play a role in preventing the leakage of faeces, flatus and urine during sexual intercourse. However, any substantial evidence for these sexual implications is lacking. In the future, more neurophysiological research as well case-control studies are needed to confirm the sexual implications of these genito-pelvic reflexes.

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